Fuel-Flexible, Low-Emissions Catalytic Combustor for Opportunity Fuels

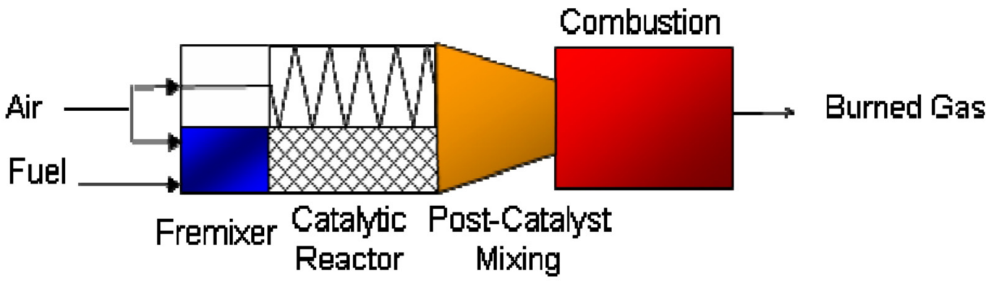
Enabling Clean Consumption of Low-Btu and Reactive Fuels in Gas Turbines

This project will develop a unique, fuel-flexible catalytic combustor for gas turbines. By enabling ultralow-emission, lean premixed combustion of a wide range of gaseous opportunity fuels, this technology could potentially displace 1.7% of industry's natural gas consumption.

Introduction

Gas turbines are commonly used in industry for onsite power and heating needs because of their high efficiency and clean environmental performance. Most often, natural gas is the fuel of choice for these turbines because of its availability, historically low cost, and consistent composition.

Opportunity fuels are unconventional fuels that have the potential to serve as an alternative to natural gas. They are often derived from agricultural, industrial, and municipal waste streams or from byproducts of industrial processes. Common examples include synthetic gas (syngas) derived from coal or biomass, anaerobic digester gas, and refinery gas from petroleum refineries.



The Rich-Catalytic Lean-burn (RCL®) combustion system, designed by Precision Combustion, Inc., will be modified for use with opportunity fuels.

Historically, typical industrial gas turbines are unable to operate effectively when powered by these opportunity fuels.

One class of opportunity fuels exhibits a low Btu heat rating, causing difficulty in achieving a stable flame, particularly in low-emissions, lean premixed combustors. The second class is high in reactive components, such as hydrogen, propane, and butane, leading to problems with destructive flashback and autoignition.

For these reasons, opportunity fuels have more commonly been used in boilers than in gas turbines, because boilers have inherent fuel flexibility and a low cost.

However, a gas turbine operating as a combined heat and power system or in a combined cycle with a steam turbine displays high efficiency and produces electricity, which has a higher energy value than steam alone from a boiler.

This project aims to address the barrier of gas turbine fuel inflexibility by developing an injector with an integrated catalytic reactor to reform opportunity fuels before normal combustion. This reforming raises the fuel temperature, changes its composition, and leads to a stable flame free of flashback and autoignition.

Benefits for Our Industry and Our Nation

The use of opportunity fuels in industrial gas turbines with catalytic combustion systems will displace natural gas consumption, produce ultralow nitrogen oxide (NO_X) emissions, reduce capital costs (when compared to use of post-combustion emission controls), and reduce or eliminate greenhouse gas emissions, particularly when biomass fuels are used.

If successfully commercialized, this technology could potentially displace natural gas consumption of 191 trillion Btu per year, or 1.7% of total industrial sector natural gas usage.

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Applications in Our Nation's Industry

Fuel-flexible catalytic combustion technology will benefit industries that utilize industrial gas turbines and have access to an alternative fuel source. Potential fuels and their sources include the following:

- Blast furnace gas from steel producers
- Refinery fuel gas from petroleum refineries
- Wellhead gas from oil and natural gas wells
- Gasification streams from solids such as coal and biomass
- Volatile organic compound streams from chemical manufacturers
- Landfill and digester gases from municipal, industrial, and agricultural waste

Project Description

The project objective is to develop a unique, fuel-flexible catalytic combustor capable of enabling ultralow-emission, lean premixed combustion of a wide range of gaseous opportunity fuels. This will broaden the range of opportunity fuels that can be utilized to include two new alternatives. The project will enable use of low- and ultralow-Btu gases, such as digester and blast furnace gases, by extending the limits of stable combustion. The project will enable use of fuels containing reactive species, such as refinery, wellhead, and industrial byproduct gases, by reforming the gases (reducing hydrogen content) to a less reactive mixture, thereby preventing early autoignition and improving turndown capability.

Barriers

- Achieving adequate catalytic contribution to stabilize the flame downstream
- Space constraints in some existing turbines will create challenges for retrofitting combustors for low-Btu fuels

Pathways

The combustor design is based on the Precision Combustion, Inc. (PCI) Rich-Catalytic Lean-burn (RCL®) combustion system.

Initially, the project will analyze the fuel mixtures and expected engine applications to determine the appropriate reactor configuration for each class of fuel.

The project will design and fabricate a set of subscale test modules and test them at expected engine inlet conditions. The project will investigate and report reactor performance and mechanisms of downstream flame anchoring.

The result of the subscale testing will provide reactor designs that can be scaled up to future full-scale single-injector fabrication and tested with gas turbine manufacturers. This single injector testing may be conducted as an optional, add-on task.

Milestones

- Demonstration of high reactor conversion for low-Btu fuels to enhance stability
- Demonstration of high preferential reaction for high-reactivity fuels to reduce flashback and autoignition
- Demonstration of low nitrogen oxide (NO_x) combustion of opportunity fuels
- Demonstration of the stable combustion of opportunity fuels with no cofiring and wide turndown capability

Commercialization

This project will result in the development of a fuel-flexible catalytic combustion system. Precision Combustion, Inc., plans to partner with gas turbine manufacturer(s) to integrate the technology into their existing turbine designs.

Once the technology is developed and validated, PCI will license it to gas turbine manufacturers for integration into their gas turbine product line. In addition, PCI will provide catalytic core manufacturing.

Project Partners

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